KOKAI PATENT APPLICATION NO. SHO 62-142733

PRODUCTION OF A FIBER-REINFORCED METAL COMPOSITE MATERIAL

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PRODUCTION OF A FIBER-REINFORCED METAL COMPOSITE MATERIAL

[*Sen'ikyohkakin'zoku fukugohzai no seizoh houhoh*]

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[*There are no amendments to this patent.*]

Specification

1. Title of the invention

Production of a fiber reinforced metal composite material

2. Claims of the invention

1. In the production of a composite in which a preform of whiskers is arranged inside the mold as the fiber skeleton and a molten metal matrix material is poured into the mold and to form a composite by pressure molding, a method of producing a fiber-reinforced metal composite characterized by the fact that the preform of the aforementioned whiskers is set in a pre-heated die insert and loaded into the mold.

2. The method of producing a fiber-reinforced metal composite described in Claim 1 of the invention in which the preform of whiskers is set in the die insert and pre-heating is done and the die is loaded into the mold.

3. Detailed description of the invention

[Field of industrial application]

The present invention pertains to an improved method for producing a fiber-reinforced metal composite material based on the pressure molding process.

[Prior art]

A whisker structure of acicular monocrystals such as SiC, Si_3N_4 and graphite exhibits excellent specific strength, specific modulus, heat resistance and chemical stability and are used as composite reinforced materials of light metals represented by Al.

As an effective means to produce a fiber-reinforced metal composite with the above-mentioned whiskers, the pressure molding process is known. As shown in Fig. 1, in the pressure molding process, assembled preform 1 is arranged inside mold 2 as the fiber skeleton, a molten metal matrix is poured into the mold, pressure is applied by plunger 4 and the molten metal matrix impregnates the preform structure and solidifies, and the most important factor in the above-mentioned method is retention of the molten state of the matrix metal under normal conditions throughout the impregnation process. When the melt is cooled during the course of impregnation and solidification of the matrix metal occurs, smooth permeation into the preform structure is blocked and problems result such as cracking of the composite member, obvious deformation of the composite, and non-uniformity of the composite structure.

Furthermore, until now, in order to achieve smooth impregnation, a method in which the melt is impregnated into the whisker preform from the top surface and side surfaces as shown by the arrows in Fig. 1, but the above-mentioned impregnation method traps gaseous components inside the preform structure or components become segregated based on reactions that occur at the time of impregnation of the melt, and result in structural defects.

[Problems to be solved by the invention]

In order to prevent premature solidification of the matrix metal, preheating of the mold and preform is commonly done. However, due to restrictions in the equipment, it is not possible to adequately heat the mold, and the molten state cannot be maintained under normal conditions throughout the impregnation process.

Moreover effective measures are not available with respect to structural segregation that accompanies full permeation of the preform.

The present invention is to eliminate all of the above-mentioned problems at the same time.

[Means to solve the problem]

The present invention is a method of producing a fiber-reinforced metal composite characterized by the fact that a preform of the aforementioned whiskers is set in a pre-heated die insert and loaded into a mold, in which process of producing a composite, the preform of whiskers is arranged inside the mold as a fiber skeleton and a molten matrix metal is poured into the mold and the composite is formed by a pressure molding process.

In the following, the present invention is explained in further detail with the explanatory drawing shown in Fig. 2.

First, preform 1 of whiskers that form the fiber skeleton is set in a pre-heated die insert 5. The preform of whiskers is produced by defibering a whisker material such as SiC, Si_3N_4 and graphite and shaping the short-fiber whiskers by the dry method or wet method, and forming into a shape based on the internal shape of the die insert 5. The die insert is made of a hard metal with high heat conductivity such as a tool steel, and the inner face is formed to achieve the final shape such as a cylinder and inverted conical shape, and the outer surface is designed to come into intimate contact with the interior wall of mold 2 when loaded. Furthermore, in addition to an integrated structure, a separable, split-mold structure can be used.

The die insert is heated in an electric furnace, etc. before loading into the aforementioned mold and pre-heated to preferably a temperature above that of the molten matrix metal. It is effective to preheat the preform of whiskers as well, and in this case, it is convenient when pre-heating is done under conditions where the preform of the whisker is mounted in the die insert.

In this case, it is possible to control the degree of shrinkage in the vertical direction of the composite through adjustment of the pre-heat temperature of the die insert and preform; thus, an the fiber volume (Vf) can be appropriately adjusted through measurements.

The die insert with the preform of whiskers mounted in it is loaded into the mold and arranged on top of lower punch 6. It is desirable when the mold is heated throughout the impregnation process by a heating unit. Subsequently, metal matrix melt 3 is poured into the mold and pressure is applied from the top with a plunger. The melt 3 impregnates from the top surface of whisker preform 1 in the direction shown by the arrows as pressure is applied. The

metal matrix melt thoroughly impregnates the entire preform structure, and solidification proceeds while the pressure is maintained.

[Work of the invention]

According to the method described above, a preform of whiskers is placed in a pre-heated die insert and impregnation with a melt is carried out; the temperature is maintained at a suitable level that makes it possible to maintain the system temperature such that the matrix metal can be maintained in a molten state. Furthermore, the matrix metal melt is impregnated in one direction from the top of the whisker preform, occluded gaseous components that exist inside the preform structure are released from the system at the bottom, and segregation of the reaction components that is likely to occur, especially when a matrix metal containing Mg is used, can be effectively eliminated.

[p. 3]

[Application Examples]

A thorough defibering was carried out for SiC whiskers with a diameter of 0.5 to 1.5 μm, length of 60 to 100 μm, density of 3.18 g/cm^3, β-type crystals and they were dispersed in purified water, then, formation of a wet whisker cake was carried out by means of a pressure filtration process, heating and drying were done to produce a column-shaped preform with a diameter of 80 mm, height of 130 mm, and fiber volume of 15%.

The above-mentioned SiC whisker preform was loaded into a die insert made of tool steel (SK material) and subsequently placed inside an electric furnace and pre-heated to a temperature of 700°C. Subsequently, the pre-heated die insert was loaded in a mold (inner diameter of 120 mm) kept at a temperature of 300°C and injection of a molten Al alloy (JIS specification 2014) at

a temperature of 800°C was carried out. Subsequently, pressure was applied from the top by a plunger at 1000 kg/cm^2, and the pressurized state was maintained until all of the melt was completely solidified.

The height of the composite area shrank to 116 mm in the Al composite reinforced with SiC whiskers produced as described above, but defects such as cracks and fissures in the structure were not observed. The photograph in fig. 3 is a vertical cross-section of the composite fused molding treated with T6, in which 7 is the composite area, 8 indicates areas where components are localized. As shown in the figure, the composite area has a uniform structure with an absence of localized component.

Furthermore, when measurements were made for gases included in the above-mentioned composite material, 5.1 cc/100 g was obtained and the local deviations were insignificant.

For comparison, the die insert was omitted and production of an Al composite reinforced with SiC whiskers was produced according to the method described above. The whisker preform in this case was arranged at the center part of the mold so that the melt was is impregnated in the direction shown by the arrows in the fig.

The composite material produced in the above-mentioned comparison example shrank to a height such that the composite area was 125 mm and the diameter was 75 mm. Fig. 4 is a photograph that shows the cross-section of the metal structure in which the cut surface was fused and treated with T6. The area with abnormal structure 9 associated with segregation of the components was observed at the center of composite region 7, and non-uniformity of the structure was observed. Furthermore, when measurements were made of the gas included in the composite material, 21.1 cc/100 g was observed at the center, 8.3 cc/100 g was observed in the

peripheral region and significantly higher values are observed than those of the example of the present invention, and an increase in the value in the center area in comparison to the peripheral region was observed.

[Effect of the invention]

According to the present invention, a uniform composite structure without segregation can be produced based on retention of normal hot-melt conditions during the course of the impregnation process when pressure molding is carried out and impregnation is done from a single direction. Therefore, the invention contributes an improved mass production technology for production of a high performance fiber-reinforced metal composite in which whiskers are used as the reinforcement material.

4. Brief description of figures

Fig. 1 is an explanatory cross-section diagram of the device used for the pressure molding process of the prior art, and Fig. 2 is a cross-section diagram of the device used for explanation of the pressure molding process of the present invention. Fig. 3 is a photograph of a cross-section of a metal structure produced by the method of the present invention, and Fig. 4 is a photograph of the cross-section of the metal structure produced by the prior art.

1 ... Whisker preform

2 ... Mold

3 ... Matrix metal melt

4 ... Plunger

5 ... Die insert

6 ... Lower punch

7 ... Composite member

8 ... Non-composite member with segregated component

9 ... Abnormal structure member

Fig. 1

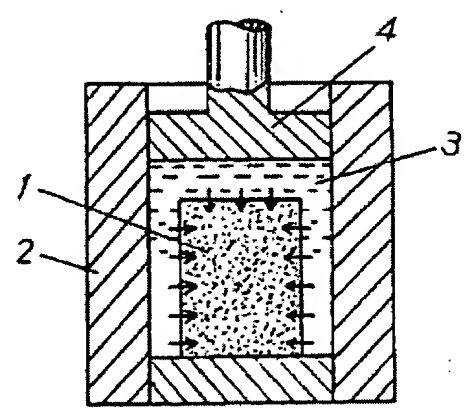

Fig. 2

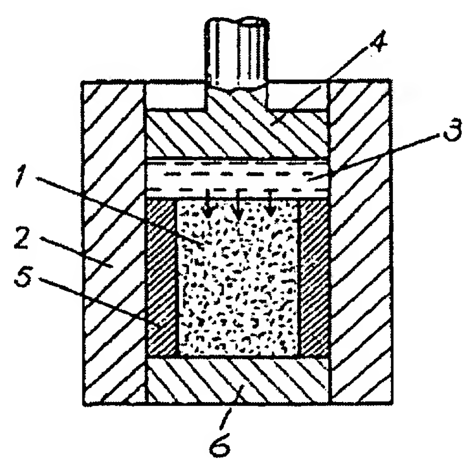

Fig. 3

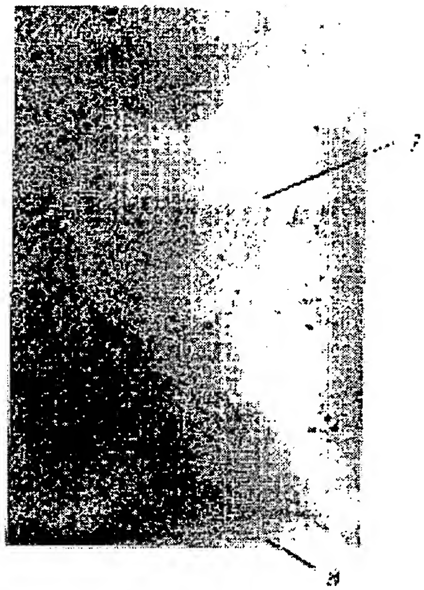

Fig. 4